29th International Cosmic Ray Conference Pune (2005) **4**, 363–366

VHE Observations of H1426+428 using TACTIC imaging telescope:2004

S.Thoudam, K.K.Yadav, R.C.Rannot, S.Sahayanathan, M.Sharma, K.Venugopal, N.Bhatt,S.Bhattacharyya, P.Chandra, V.K.Dhar,H.C.Goyal, S.Godambe, R.K.Kaul, M.Kothari, S.Kotwal, R.Koul and A.K.Tickoo

Nuclear Research Laboratory, Bhabha Atomic Research Centre, Mumbai-400085, India

Presenter: S.Thoudam (satyend@barc.ernet.in),ind-thoudam-S-abs1-og23-poster

The BL Lac object H1426+428 (z=0.129) is an extreme synchrotron blazar and is a potential source for TeV γ-rays. The Whipple, HEGRA and CAT collaborations have reported VHE γ-ray detections from this object in 2002. We have also observed this source using the TACTIC imaging element (E_{th} >1.5 TeV) in the on/off mode of observation during the period March-April 2004. A total of $\approx$ 69 hours of clean data were recorded from the on-source direction. Detailed data analysis results do not show any evidence for the presence of a statistical significant TeV gamma-ray signal from the source direction. We have placed an upper limit of 0.2×10^{-11} photons cm^{-2} sec^{-1} at 3σ confidence level on its VHE emission above threshold energy of TACTIC telescope.

1. Introduction

The extragalactic object H1426+428 is an established member of the class of extreme synchrotron BL Lac objects [6]. The synchrotron peak of "extreme blazars" can occur at energies greater than 100 KeV and in the frame work of synchrotron self-Compton (SSC) models, the corresponding ultrarelativistic electrons can give an inverse compton peak which lies in the TeV region. In the VHE band, earlier detection of this source at a flux level of $\approx$ 0.06 Crab units was made by the Whipple group at a statistical significance of $\approx 5.8\sigma$ [4] and subsequent confirmation of the source was then reported by the CAT and HEGRA [1,3] groups. The energy spectrum of the source has been found to be quite steep between 350 GeV to 1 TeV with a power law spectral index of 3.50$\pm$0.15 and 3.66$\pm$0.41 measured by the Whipple and CAT groups, respectively. On the other hand, the HEGRA group had reported a spectral index of 2.6$\pm$0.6 between 700 GeV to 1.4 TeV, which the authors claim to be consistent with the expected signature of the absorption of TeV gamma-rays by the inter galactic infrared photons. For the given red-shift of z= 0.129, any detection of a signal at TeV energies indicates a very high luminosity of the source.

2. Experimental details

TACTIC array of atmospheric Cerenkov telescopes is located at Mt. Abu (24.6° N, 72.7° E, 1300 m asl), Rajasthan, in Western India. Its Imaging Element (IE) uses a tessellated light-collector of 9.5 m^2 area which is configured as a quasi-parabolic surface, yielding a measured spot-size of $\sim$ 0.3° for on-axis rays. The PC-controlled 2-axes drive system of the telescope ensures a pointing / tracking accuracy of 5 arc-mins and the pixel resolution of its imaging camera is $\sim$ 0.31° throughout the camera FoV of $\sim$ 6° $\times$ 6°. We have used 225 pixels of the camera for present observations and the event-trigger generation is based on the 3NCT (Nearest Neighbour Non-Collinear Triplets) topological logic, demanding $\geq$ 7 pe's for the 3 pixels which participate in the trigger-generation. Whenever the single's rate of one or more pixels goes beyond the preset operational band, it is automatically restored to within the prescribed range by appropriately adjusting the pixel(s) high voltage(s). The resulting change in the pixel(s) gain is monitored by repeatedly flashing a bright LED lamp,

Table 1. Observation spells: 2004(On source)

Month	Dates	Observation time (hrs)
March	21, 22, 23, 24, 25, 27, 28, 29, 30	29.61
April	12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 23, 24, 25, 27	39.72

improvised to produce a homogeneous light field over the entire camera body [2]. From the logged digital counts (dc), the relative gains of all the pixels are derived with respect to 4 'calibration' pixels for which the high voltage is always kept fixed. The absolute calibration and the sky pedestal data (dc) of the camera pixels are recorded several times during the course of observations for Cerenkov image-cleaning and calibration purposes.

3. Observations and analysis

The night sky background (NSB) in Mt. Abu, where the telescope is located is $\approx (1.4 \pm 0.5)\times10^{12}$ photons $cm^{-2}sec^{-1}sr^{-1}$ and the estimated threshold of the telescope is $\approx$ 1.5 TeV. The observation of H1426+428 was carried out both in the On- and Off-source modes during March-April 2004 and clean data of 69.33 hours and 7.17 hours respectively were collected. In view of less observation time in the Off-source mode, only the On-source data was used for analysis.

We selected only the clean data taken under good sky conditions. The selected observation spells are given in Table 1. The data contains the Cherenkov photon count and the background sky count, which is comprised of the night sky background (NSB) photons and electronic noise. This noise was removed as follows: Firstly, from the total count recorded, the mean of the background sky pedestal count was subtracted. Secondly, We applied a two level noise filter which involves : (a) the acceptance of only those pixels with final count (C) $\geqslant$ picture threshold (P.T= 6.8σ) as "picture" pixels and (b) those with C $\geqslant$ boundary threshold (B.T= 3σ) and associated with at least one picture pixel as "boundary" pixels. Here, "σ" is the RMS sky pedestal deviation. Then, the remaining pixels were set to zero count. The images retrieved using the procedure described above can be generated both by the very high energy (VHE) γ-rays and the huge hadronic cosmic ray background. The discrimination of the γ-ray-like events from the cosmic-ray-like ones was done by adopting the standard "Imaging Technique" [5,7-9] which uses image parameters like "Length", "Width", "Distance" and "Alpha". Since, those images with number of pixels less then 4 cannot give the image parameters correctly, we accepted only those with number of pixels more than 3. Furthermore, this filter effectively removes events generated by muons passing through the camera. The image parameters used and the gamma domain cut values adopted in the present analysis are given in Table 2.

4. Result and Discussion

The data analysis procedure described above was applied to the data accumulated during March-April 2004. As already mentioned, because of the limitation of data in the Off-source mode, the hadronic cosmic ray background was estimated from the On-source data itself and is shown by the horizontal line in Fig.1 together with the "alpha" distribution of those events which survive the γ domain cut values given in Table 2. No significant excess of gamma ray events was detected and we derived a three sigma upper limit flux of 0.2×10^{-11} photons

Table 2. γ domain cut values for image parameters

Parameter	value
Size	$\geq$ 485.0
Length	0.11 $\leftrightarrow$ 0.155+ 0.0260$\times$log(size)
Width	0.06 $\leftrightarrow$ 0.08+ 0.0125$\times$log(size)
Distance	0.4 $\leftrightarrow$ 1.3
Alpha	$\leq$ 15°
frac2	$\geq$ 0.38

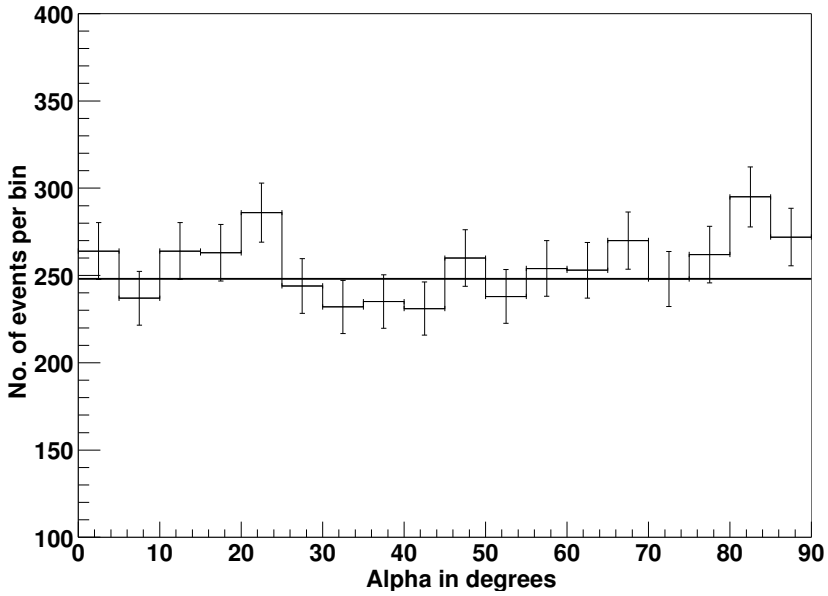

Figure 1. Alpha distribution of cherenkov events. The estimated hadronic cosmic ray background is shown by the horizontal line.

$cm^{-2}sec^{-1}$. In Fig.2, we have shown the daily rates (no. of gamma events per hour) for the same data set and we do not find the presence of any significant signal on daily basis also.

5. Conclusions

We have observed the source H1426+428 with the TACTIC cherenkov telescope during the period March-April 2004. The observation did not yield a significant detection of gamma-rays from the source and we derived an upper limit flux of 0.2×10^{-11} photons $cm^{-2}sec^{-1}$ above 1 TeV.

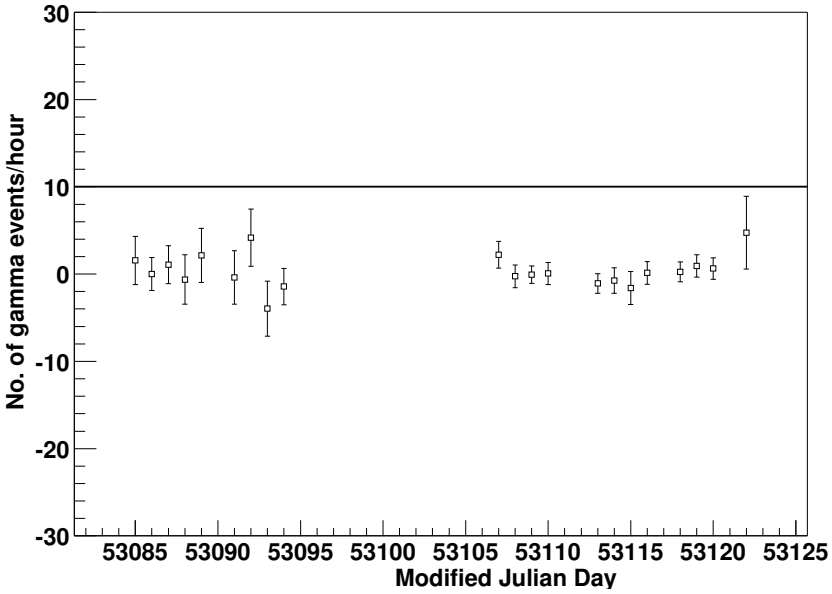

Figure 2. Daily hourly gamma-ray rates during the period March-April 2004. The horizontal line is the rate expected from the Crab Nebula.

6. Acknowledgements

We would like to thank all the colleagues of NRL division for their deep involvement and contribution towards the observation and the data analysis aspects of the telescope.

References

[1] Aharonian, F., et al., Astron. and Astrophys., 384 (2002) L23.
[2] Bhatt N, et al., 2001, Meas. Sci. Technol, 12, 167.
[3] D.Djannati-Atai et al., Astron. and Astrophys., 391 (2003) L25.
[4] D.Horan et al., Ap. J., 571 (2002) 753.
[5] Hillas, A.M. 1985, Proc. 19th ICRC(La jolla), 73, 51.
[6] Remillard R. A. et al. 1989, ApJ 345, 140
[7] Tanimori, T., et al. 1998, ApJ, 492, L33.
[8] Tanimori, T., et al. 2001, Proc. 27th ICRC (Hamburg), 6 2465
[9] Weeks, T.C., et al. 1989, ApJ, 342, 379